Task 2.2

What are the seasonal, day-to-day and diurnal variations in PM mass and chemical components and in PM precursor species? How do these vary spatially and by season? What are the relations between PM_{10} and $PM_{2.5}$ variations and other pollutants?

1. Introduction

The PM concentrations in California vary seasonally depending on the nature of predominant emission sources and meteorological factors. The seasonality is most pronounced in the San Joaquin Valley, where PM_{10} concentrations are highest in fall and early winter and $PM_{2.5}$ concentrations are highest in winter. Other air basins in California, like the San Francisco Bay Area, Sacramento Valley, San Diego, North Coast, and Mojave Desert, exhibit similar but less pronounced seasonality. The South Coast Air Basin, where $PM_{2.5}$ concentrations are uniform throughout the year, is rather unique compared to other areas of California.

Significant variations in PM concentrations can also occur over a very short time-scales, such as a few days, hours, or even minutes. Diurnal PM variations provide evidence of the influence of local sources on PM concentrations.

Spatial and temporal analysis of PM concentrations show significant variations from place to place. Under episodic conditions, winter PM concentrations build up over several days and result in a wide spread pollution episode. For example, an extensive regional episode in the San Joaquin Valley began on December 19, 1999 and continued through December 30, 1999. The entire San Joaquin Valley recorded many exceedances during this 12-day period, with some of the highest concentrations during the periods between December 22 and 26. $PM_{2.5}$ concentrations varied from near the 24-hour standard of 65 ug/m3 to as high as 134 ug/m3 at Fresno-1st Street. Concentrations above the $PM_{2.5}$ 24-hour standard were also reported in the San Francisco Bay Area and the Sacramento Valley Air Basin.

2. Objectives

The objective of this task is to analyze variations in PM mass, chemical species, and precursor concentrations over different time scales and among the sites. The specific objectives are listed below.

A. Seasonal Variations

- Examine seasonal variations in PM_{10} and $PM_{2.5}$ mass, chemical components, and PM precursors.

- Determine correlation between historical seasonal pattern and pattern exhibited by CRPAQS data.
- Examine meteorological conditions associated with high PM_{10} and $PM_{2.5}$ seasons.

B. Day-to-Day Variations

- Examine day-to-day variations in PM_{10} and $PM_{2.5}$ mass, chemical components, and PM precursors.
- Examine variations in spatial average concentrations.
- Examine variations in temporal average concentrations.
- Calculate spatial and temporal coefficient of variation.
- Compare the magnitude of day-to-day variations to site-to-site variations.
- Prepare time series plots of concentrations grouped by site type (i.e., industrial, agricultural, commercial/residential) and by region (North Coast, South Valley, Bay Area, foothill, boundary).
- Analyze variations within a group.
  - Do all sites in the group follow the same temporal pattern?
  - What is the relationship between the temporal pattern and meteorology?
- Compare variations between groups of sites.
- Cluster days based on concentration data across all monitoring sites to identify and characterize pollution episodes.
- Cluster sites within the study domain based on average concentrations. Examine sites within a cluster based on location and site type.

C. Diurnal Variations

<u>Hourly Concentrations</u>

- Examine diurnal patterns in PM_{10} and $PM_{2.5}$ mass, species, and PM precursors.
- Describe seasonal differences in diurnal patterns.
- Compare the diurnal patterns associated with the following conditions:
  - Rainy vs. non-rainy days.
  - Foggy vs. non-foggy days.
  - Weekday vs. weekend.
  - Holiday vs. non-holiday.

<u>Hourly Concentrations Versus 24-hour Average Filter Based Concentrations</u>

- Evaluate relationship between 24-hr average concentrations and peak hourly concentrations.
  - Compare daily statistics for hourly mass and speciation data (where available), including maximum, minimum, and average, to 24-hour average data.
  - Compare the 1-hr average data to the level of the corresponding 24-hour standard. Examine the days with 1-hr average concentration above the standard and 24-hour average concentration below the standard. Characterize the difference in concentrations.
- Compare the 1-hr average concentrations to 24-hr averaged concentrations to evaluate the utility of data collected using BAM sampler versus sequential filter-based sampler.

Hourly Concentrations Versus Filter Based Concentrations Less Than 24 Hours

As part of the 15-days of episodic monitoring during CRPAQS Winter Campaign, five anchor sites collected five samples per day over the periods of 0000-0500, 0500-1000, 1000-1300, 1300-1600, and 1600-2400. These data will be compared to 1-hour data. The comparison will be similar to that for 24-hour data. We will compare diurnal patterns and daily statistics of hourly and filter-based concentrations.

D. Co-variation of PM with Other Air Pollutants.

Particle sources are either primary-directly emitted, or secondary-formed via reactions in the atmosphere. The relative contributions of primary and secondary sources differ depending on location, season, and meteorology. Coarse particles ($PM_{2.5}$ to PM_{10}) are usually primary in nature and they result from both mechanically suspended and windblown dust. Ozone concentrations are highest during stagnant conditions, when windblown dust would typically be at a minimum. Therefore we generally should not see a correlation between high ozone and coarse particle concentrations due to windblown dust (but may see correlation for mechanically suspended dust associated with motor vehicles and agricultural activities).

Many fine particles are secondary in nature. They have the same precursor species as ozone (VOC and NOx). Ozone and fine particles are both formed under the stagnant conditions. However, other meteorological factors that promote ozone formation, like radiation and high temperature, hinder fine particle formation. Therefore we anticipate certain amount of correlation between ozone and fine particles on a daily scale, but not on an annual scale. Other fine particle sources such as wood combustion would not be significant under high ozone conditions.

We will also examine correlations between PM concentrations and other pollutants. One of the pollutants we will examine is CO. CO accumulates and fine particles are formed under stagnant conditions and share some of the same emission sources. We will also evaluate correlations between PM concentrations and fine particulate matter precursors, NOx, VOC, and SO2.

The specific objectives are:

- Examine correlation between high concentrations of both $PM_{2.5}$ and PM_{10}. Determine when and where high PM_{10} concentrations coincide with high $PM_{2.5}$ concentrations.
- Examine correlations between PM and other pollutants, including ozone, CO, NOx, SO2, and VOC.
  - Examine correlation on a daily scale.
  - Examine correlation in diurnal profiles.
  - Examine correlation between high concentration of PM and high concentrations of ozone, CO, NOx, SO2, and VOC.

3. Technical Approach

A. Data Included in the Analysis

The following ambient data from routine network and CRPAQS will be used in the analysis:

- Dichot PM_{10} and $PM_{2.5}$.
- SSI PM_{10}
- FRM $PM_{2.5}$.
- DRI SFS PM_{10} and $PM_{2.5}$.
- Minivol PM_{10} and $PM_{2.5}$
- BAM PM_{10} and $PM_{2.5}$.
- Gaseous data including Ozone, CO, NOx, SO2, NH3 and VOC.
- Other continuous PM (nitrate, sulfate, OC/EC, aethalometer).
- Filter-based chemical components

B. Types of Analyses

<u>Seasonal</u>

- Calculate monthly average $PM_{2.5}$ and PM_{10} ambient concentrations, concentrations of chemical components, and of PM precursors.
- Construct graphs of monthly average concentrations.

- Analyze meteorological data to describe conditions associated with each season.
- Review data and graphs for patterns.

<u>Day-to-Day</u>

- Prepare a table summarizing number of samples, average, standard deviation, and a maximum for each category of sites.
- Prepare graphs and maps to illustrate spatial variations in PM concentrations on high PM days.
- Prepare time series of plots of concentrations grouped by site type and by region. Analyze variations within a group and between groups.
- Group days with similar meteorology and analyze temporal patterns within each group.
- Calculate spatial and temporal coefficient of variation. Compare the magnitude of day-to-day variations to site-to-site variations.
- Group days with similar concentration using a cluster analysis technique. Analyze variations within a group and between groups.
- Group sites with similar concentrations using Euchidian Distance and Correlation "similarity" analyses. Analyze variations within a group and between groups.

<u>Diurnal</u>

- Calculate standardized 1-hr average concentrations by subtracting the daily average from 1-hour average concentrations and dividing by the daily standard deviation.
- Construct diurnal plots of hourly concentrations. Review plots for magnitude of variations and patterns.
- Construct diurnal plots of hourly concentrations standardized by day. Review plots for patterns.
- Examine the magnitude of variation in concentrations within a day, from day-to-day, and from site-to-site.
- Group the data based on meteorological conditions (i.e., separate the rainy days from non-rainy days and foggy days from non-foggy days) and compare the diurnal patterns within a group and between groups.
- Group the data based on the activity level (i.e., weekend vs. weekdays, holidays vs. non-holidays).
- Construct graphs and tables to illustrate the relationship between the 1-hour average concentrations and the relevant 24-hour average standard. Examine differences between peak 1-hour and 24-hour average concentrations. Examine days when 1-hour average

concentrations frequently exceed the level of the 24-hr average standard but the 24-hour average concentrations were below the standard.

Hourly Concentrations Versus Filter-Based Concentrations Less Than 24 Hours

- Calculate standardized concentrations averaged over a sampling period by subtracting the daily average from period-average concentrations and dividing by the daily standard deviation.
- Construct diurnal plots of period-averaged concentrations. Review plots for magnitude of variations and patterns.
- Construct diurnal plots of period-averaged concentrations standardized by day. Review plots for patterns
- Examine the magnitude of variation in concentrations within a day, from day-to-day, and from site-to-site.
- Group the data based on meteorological conditions (i.e., separate the rainy days from non-rainy days and foggy days from non-foggy) and compare the diurnal patterns within a group and between groups.

4. Schedule and Deliverables

The schedule for completion of milestones is shown in Table 3.

Table 3. Schedule

Completion Date	Task
October 2002	Calculate data statistics.
November 2002	Prepare graphs and maps to illustrate seasonal variations, spatial variations, temporal variations, diurnal patterns, relationships between hourly data and 24-hour standard.
December 2002	Analyze data for patterns. Examine magnitude of variations. Summarize preliminary findings.
January 2003	Group data based on meteorological conditions. Analyze data within a group. Compare groups.
February 2003	Analyze data for patterns. Examine magnitude of variation. Summarize preliminary findings.
March 2003	Perform additional calculations and construct graphs in response to preliminary findings.
April 2003	Prepare final data summaries and

	graphs.
May 2003	Prepare final report.